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INT CL^5 H04R 9/00 9/02 9/06

(54) Loudspeaker including magnetic flux cancellation coil

(57) The loudspeaker drive unit includes a compensation coil 130 having 40 - 120% of the number of turns in the voice coil 123. The compensation coil is wound in the opposite direction to the voice coil and is connected in series with the voice coil. The compensation coil is mounted on the central portion of the magnet system.

The compensation coil 130 thus counteracts the AC magnetic flux generated due to the motion of the voice coil 123 and so improves the quality of the drive unit by reducing sound distortion.

FIG.11

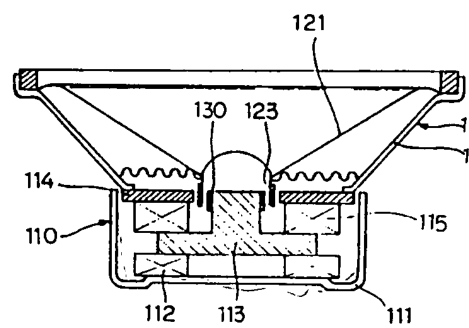
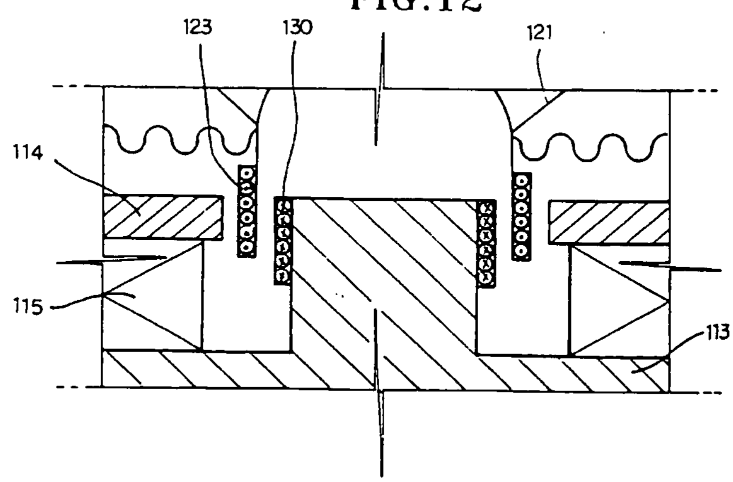


FIG.12



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.

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SPEAKER

The present invention relates to a speaker having a function for compensating for soundpressure distortion, and more particularly to a speaker, wherein a compensating coil winding in the reverse direction of a voice coil is attached in the inside the speaker to have a phase difference of 180 with an AC magnetic flux component induced between the voice coil and upper and lower plates for counteracting the AC magnetic flux component, thereby minimizing distortion of sound pressure to improve sound quality of a speaker unit.

Generally, a speaker is formed of a driving portion for supplying a driving source to upwardly and downwardly vibrate a vibrating plate, and a vibration portion for obtaining a constant sound pressure according to the vibration of the vibrating plate in the up-and-down direction. The speaker is largely categorized into an inner-magnetic type, an outer-magnetic type and a cone-magnet type in accordance with the constituents of the driving portion.

The inner-magnetic type speaker has a shield case on the outer side of the magnet. The outer-magnetic type speaker has upper and lower plates mounted on the upper and lower surfaces of the magnet and an auxiliary magnet covered with a shield case is installed on the lower surface of the lower plate.

FIGS. 1 and 2 show a sectional view and an enlarged view of a principal portion showing a cone-magnet type speaker according to a conventional technique.

In these drawings, a driving portion 10 includes a ring-shaped auxiliary magnet 12 attached within a shield case 11, a lower plate 13 which is shaped as an upside-down "T" attached on the upper end of the auxiliary magnet 12, a ring-shaped upper plate 14 and a ring-shaped main magnet 15 between the lower plate 13 and upper plate 14. As shown in FIG. 1, a predetermined void is provided between the lower plate 13 and upper plate 14.

A vibration portion 20 which vibrates by the driving portion 10 has a cone-shaped vibrating plate 21 on the upper end of the upper plate 14, a frame 22 for supporting the vibrating plate 21, and a voice coil 23 winding around the outer circumference of the vibrating plate 21 and placed in the void between the lower plate 13 and upper plate 14.

Here, the void in the driving portion 10 refers a range from the upper end to the lower end of the voice coil 23 during the upward and downward vibration thereof in the spacing between the lower plate 13 and upper plate 14.

In the conventional cone-magnet type speaker, under the state that

DC magnetic flux is interlinked in the void between the upper and lower plates 14 and 13 due to the main magnet 14 and auxiliary magnet 12, current (negative current) flows along the voice coil 23 to initiate the up-and-down movement of the voice coil 23 in conformity with a Fleming's rule of left hand.

Together with the up-and-down movement of the voice coil 23, the vibrating plate 21 integrally formed with the voice coil 23 also vibrates upward and downward to cause a predetermined sound pressure.

On the other hand, the flow of the magnetic flux existing in the magnetic circuit within the speaker is classified into two: one is the DC magnetic flux component by the magnet shown in FIG. 3, and the other is AC magnetic flux component by the voice coil as shown in FIGS. 4A to 4D. Since the magnet continuously supplies constant magnetic flux distribution to the void regardless of time, the magnetic flux distribution shown in FIG. 3 is consistent at any time. But the AC current (negative current Iac equals to Im COSωt) sinusoidally varies in conformity with time, so that the flow of the magnetic flux is continuously changed as shown in FIGS. 4A to 4D.

For example, in FIG. 4B, if ωt=90 , the AC current Iac becomes zero (i.e., Im COS 90 = 0), but the magnetic flux is continuously produced by induced current from the upper and lower plates. The AC magnetic flux exists within the magnetic circuit while overlapping the DC magnetic flux, and the AC magnetic flux of the void is 15% or so of the DC magnetic flux in a nominal input state.

The distribution of the AC magnetic flux varies in accordance with

frequencies for the reason that the amount of the induced current generated between the upper and lower plates varies in accordance with the frequencies to differently affect a magnetic field. Moreover, as the frequency becomes higher, the flow of the magnetic flux concentrates on the surface due to the induced current, as illustrated in FIGS. 5A to 5D.

As shown in FIGS. 5A to 5D, the higher the frequency is, the more magnetic flux concentrates around the void of the voice coil to be inclined to form a symmetry of positive (+) and negative (-) with respect to the radius direction. When positive and negative are perfectly symmetrical in the radius direction with respect to the center of the void, the amount of the AC magnetic flux Iac of overall void becomes zero, so that the distorted component force caused by the AC magnetic flux, which will be described later, may disappear.

Meanwhile, a driving force (F = B · L · I) that pushes or pulls the voice coil is generated by the negative current supplied to the voice coil. If an aural waveform supplied with this force is reproduced unchanged, distortion does not occur in the concept of the magnetic circuit. However, in connection with the basic theory of the electromagnetic field, the distortion of the main magnetic field due to the negative current is inevitable to produce a variation factor of the driving force F. Additionally, the up-and-down movement of the voice coil may involve variations in the magnetic force according to the position of the voice coil. Although the driving force F is ideally generated, the reason of causing the distortion by the vibrating portion

still remains.

Hereinbelow, in the void, the relation between the AC magnetic flux Φ ac and the driving force F of the voice coil will be described.

When an average magnetic flux density is written by B gap,

$$Bgap = Bdc + (|\Phi\ ac|/A) \cdot SIN(\omega t + \alpha) \quad \text{------} \quad (I)$$

where, Bdc designates the DC magnetic flux density of the void, A is an area of the void, $|\Phi\ ac|$ is the maximum amount of Φ ac, $|\Phi\ ac|/A$ is the maximum value of the AC magnetic flux density, ω is respective frequencies of the negative current, and α is a phase difference between the negative current and the DC magnetic field cause by the negative current.

Assuming that the negative current i equals to im SIN(ωt) and an effective coil length affected within the void is defined by l, the driving force F will be obtained by,

$$F = Bgap \cdot l \cdot i \quad \text{-----------------} \quad (II)$$

$$= \{Bdc + (|\Phi\ ac|/A) \cdot SIN(\omega t + \alpha)\} \cdot l \cdot im\ SIN(\omega t)$$

$$= Bdc \cdot l \cdot im\ SIN(\omega t) - \tfrac{1}{2}(|\Phi\ ac|/A) \cdot l \cdot im\ COS(2\omega t + \alpha)$$

$$+ \tfrac{1}{2} \cdot (|\Phi\ ac|/A) \cdot l \cdot im\ COS(\alpha)$$

The first term of equation II is the component of the driving force F without the distortion caused by the negative current. The third term thereof is a bias component by the AC current, in which the force

exerting in a constant direction (upward or downward) during vibrating the voice coil is in proportion to the amount of the AC magnetic flux and relates to the phase difference α. The second term thereof is the frequency component twice the driving force F caused by the AC magnetic flux component Φac, and brings about second distortion component (second harmonic component) in the driving force F. The content rate of the second distortion component can be calculated as below:

$$k = \frac{\text{the second term component of F (second harmonic frequency)}}{\text{the first term of F (fundamental frequency)}}$$

$$= \frac{|\Phi ac|}{2 \cdot Bdc \cdot A} \qquad \text{--- (III)}$$

$|\Phi ac|$ which is the average AC magnetic flux density component by the negative current may be heightened up to 0.075(7.5) since this absolute value can be raised by approximately 15% of the DC magnetic flux density B dc during the nominal input.

The absolute value K in the equation III can be reduced by allowing the DC magnetic flux density component Bdc to be greater than the maximum value of the AC magnetic flux density $|\Phi ac|/A$, or reducing the AC magnetic flux density Φac.

However, the augmentation of the DC magnetic flux density component Bdc is not always preferable because a suitable magnitude may exist within the speaker unit.

When the same energy level is supplied, the value Φac is relatively great under a lower frequency. Thus, to lower the value Φac is to heighten an effect of decreasing the distortion in a low area.

More than three times distortion may appear in the magnetic circuit. The major reasons thereof is a hysteresis property of the material constituting the upper and lower plates, and the variation factor of the driving force due to the vibration of the voice coil, etc.

If the distortion by the hysteresis is added to the B gap component in equation III (provided that the influence by the hysteresis owes to the harmonic frequency component), another sine component is multiplied to the Bgap component to draw out the second harmonic frequency from the fundamental frequency and the third component from the second distortion of the DC. Therefore, by reducing the second component, the third component by the magnetic circuitry is decreased, otherwise a plate material with less hysteresis phenomenon should be used to decrease the third component.

In other words, as shown in FIG. 6, the conventional cone-magnet type speaker is disadvantageous in that the current flowing through the voice coil 23 winding one end of the vibrating plate 21 generates the AC magnetic flux without fail to make the magnetic flux density in the void between the lower plate 13 and upper plate 14 out of balance, which in turn produces distortion in the up-and-down movement of the voice coil 23, thereby resulting in the distortion of the sound pressure.

A speaker devised to solve the above problem is illustrated in FIGS. 7 and 8, in which the same reference numerals as used in FIGS. 1 and 2 designate the like parts, and thus detailed description of them will be omitted.

As can be noted from FIGS. 7 and 8, a pole cap 30 formed of copper

is attached on the upper end of the lower plate 13 sandwiched between the ring-shaped main magnet 15 and the auxiliary magnet 12.

In this cone-magnet type speaker, as shown in FIGS. 9 and 10, when current flows along the voice coil 23 winding the vibrating plate 21, the induced current is generated within the pole cap 30 attached on the upper end of the lower plate 13 to control the AC magnetic flux by the voice coil 23.

However, the induced current incited for counteracting the AC magnetic flux in the pole cap 30 attached on the upper end of the lower plate 13 theoretically has a time phase difference of 90° , so that the counteraction effect is imperfect (that of 180° is perfect). Therefore, the magnetic flux density is out of balance in the void between the upper plate 14 and the lower plate 13 to distort the up-and-down movement of the voice coil 23, which distorts the sound pressure.

Furthermore, the induced current is produced on the upper and lower plates 14 and 13 to cause thermal loss (iron loss) owing to resistance, and the AC magnetic flux encroaches into the lower and upper plates 13 and 14 to bring about hysteresis loss.

SUMMARY OF THE INVENTION

The present invention is contrived to solve the above-described problems. Accordingly, it is an object of the present invention to provide a speaker, wherein a compensation coil serially connected to but reversely winding a voice coil is installed around a void between an

upper plate and a lower plate for allowing a current phase difference to be 180° by the winding direction of the compensation coil reverse to that of the voice coil, so that AC magnetic flux is counteract to lessen the amount of the AC magnetic flux and thus minimize sound pressure distortion, thereby contriving the improvement of sound quality in a speaker unit.

It is another object of the present invention to provide a speaker, wherein a compensation coil winds around a void between upper and lower plates by a half or nearly the same number of turns of a voice coil to reduce AC magnetic flux and induced current between the upper and lower plates, thereby decreasing thermal loss (iron loss) and hysteresis loss.

In order to achieve the above object of the present invention, there is provided a speaker which includes a DC magnetic field generation apparatus having first and second magnets, an upper plate and a lower plate forming a magnetic path of the DC magnetic field generation apparatus, and a voice coil for converting an electrical sound signal into a mechanical sound signal in a void between the upper plate and lower plate. The speaker further includes an AC magnetic flux offset unit to allow magnetic flux produced for counteracting an AC magnetic flux component induced between the voice coil and the upper and

Also, the AC magnetic flux offset unit is formed of AC magnetic field offset unit having a phase difference of 180° with an AC magnetic field for counteracting the AC magnetic field induced between the voice coil and first magnet.

In the present invention, the sound current source offset unit is a compensation coil winding as many as 80 to 120% with respect to the number of turns of the voice coil on an outer circumference of an upper portion of the lower plate projecting at a groove in a lower portion of the void, and serially connected to the voice coil.

Preferably, the AC magnetic field offset unit is a compensation coil winding as many as 40 to 60% with respect to the number of turns of the voice coil on the central portion of upper and lower ends of the lower plate projecting at the groove in the lower portion of the void, and serially connected to the voice coil.

Furthermore, the compensation coil winds around the lower end of the lower plate projecting at the groove in the lower portion of the void.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a sectional view showing a conventionally general cone-magnet type speaker;

FIG. 2 is a detailed view of an enlargement showing a principal portion of FIG. 1;

FIG. 3 is a distribution of a DC magnetic field produced by the magnet in the speaker shown in FIG. 1;

FIGS. 4A to 4D show the distribution of an AC magnetic field by the voice coil;

FIGS. 5A to 5D are distribution of the AC magnetic flux according to frequencies;

FIG. 6 is a distribution of the magnetic flux density in the void of the speaker shown in FIG. 1;

FIG. 7 is a sectional view showing another conventional speaker having a pole cap;

FIG. 8 is a detailed view of an enlargement showing the principal portion of FIG. 7;

FIG. 9 is a distribution of the magnetic flux at the frequency of 30Hz in the speaker shown in FIG. 7;

FIG. 10 is a distribution of the magnetic flux density in the void of the speaker shown in FIG. 7;

FIG. 11 is a sectional view showing one embodiment of a speaker according to the present invention;

FIG. 12 is a detailed view of an enlargement showing a principal portion of FIG. 11;

FIG. 13 is a distribution of the magnetic flux density in the void of the speaker shown in FIG. 11;

FIG. 14 is a distribution of an AC interlinking magnetic flux

density at the compensation coil shown in FIG. 11;

FIG. 15 is a sectional view showing another embodiment of a speaker according to the present invention;

FIG. 16 is a detailed diagram of an enlargement showing the principal portion of FIG. 15;

FIG. 17 is the distribution of magnetic flux at a frequency of 30Hz in the speaker shown in FIG. 15;

FIG. 18 is the distribution of a magnetic flux density in the void of the speaker shown in FIG. 15; and

FIG. 19 is the distribution of an AC interlinking magnetic flux density at the compensation coil shown in FIG. 15.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 11 and 12 showing one embodiment of a speaker according to the present invention, the speaker has a driving portion 110. The driving portion 110 includes a ring-shaped auxiliary magnet 112 attached within a metal shield case 111, and a ring-shaped main magnet 115 sandwiched between a lower plate 113 shaped as an upside-down "T" attached on the upper end of the auxiliary magnet 112 and an upper plate 114.

A vibration portion 102 includes a frame 122 having a cone-shaped vibrating plate 121 on the upper end of the upper plate 114, in which a voice coil 123 is formed on the central portion of the vibrating plate 121 to be placed within a void between the lower and upper plates 113

and 114.

A compensation coil 130 winding in the reverse direction of the voice coil 123 but having nearly the same number of turns is attached on the outer circumference of the upper end of the lower plate 113 being the void portion between the lower plate 113 and upper plate 114. The compensation coil 130 is serially connected to the voice coil 123.

The number of turns of the compensation coil 130 has preferably 80 to 120% with respect to the voice coil 123, and the more preferable number of turns thereof is the same as that of the voice coil 123.

In the speaker formed according to one embodiment of the present invention, the current (negative current) flows along the voice coil 123 under the state that the DC magnetic flux is interlinked in the void between the upper and lower plates 114 and 113 by the main magnet 115 and auxiliary magnet 112, thereby initiating the up-and-down movement of the voice coil 123 in conformity with a Fleming's rule of left hand.

Along with the up-and-down vibration of the voice coil 123, the vibrating plate 121 integrally formed with the voice coil 123 also vibrates upward and downward to generate a predetermined sound pressure.

At this time, if current flows along the voice coil 123, the AC magnetic flux becomes produced, and another AC magnetic flux is produced by the compensation coil 130 serially connected to the voice coil 123.

In other words, the AC magnetic flux produced by the voice coil 123 is distributed in the upper portion around the void, while the AC magnetic flux generated by the compensation coil 130 is distributed in the lower portion around the void to allow the AC magnetic flux to be

symmetrically distributed as shown in FIG. 13.

That is, as shown in FIG. 12, the upper compensation coil 130 which winds as many as the turns of the voice coil 123 in the reverse direction thereof and installed on the upper portion of the lower plate 113 is to counteract a negative current source which causes the AC magnetic field. Since the current in the reverse direction flows just beside the voice coil 123 along the same turns of coil, so that the sum of overall current becomes zero throughout the void.

Accordingly, the AC magnetic flux generated by the voice coil 123 and compensation coil 130 has the current phase difference of 180° to be symmetrical to each other, thereby counteracting the AC magnetic flux.

Therefore, as shown in FIGS. 13 and 14, the speaker according to one embodiment of the present invention has little amount of the AC magnetic flux generated between the upper and lower plates 114 and 113 regardless of the frequencies, and the AC magnetic flux components around the void form a perfect symmetry by positive and negative to exhibit an excellent offset effect of the AC magnetic field.

In more detail, the excellent offset effect of the AC magnetic field denotes that, when the vibrating plate 121 integrally formed with the voice coil 123 vibrates upward and downward along with the up-and-down movement of the voice coil 123 by the current (negative current) flowing through the voice coil 123, the AC magnetic flux inevitably generated by the current of the voice coil 123 is decreased by the compensation coil 130, and inconsistent magnetic flux density is prevented in the void between the upper plate 114 and lower plate 113.

So the distortion with respect to the up-and-down movement of the voice coil 123 is prevented and compensated to minimize the distortion of the sound pressure.

Also, the pole cap 30 of the lower plate 113, which was the requisite component of the conventional technique is not needed to reduce the AC magnetic flux, so that the induced current at the upper and lower plates 114 and 113 is decreased, and the thermal loss (iron loss) and hysteresis loss are reduced.

In the speaker according to one embodiment of the present invention as described above, since a compensation coil which winds approximately as many as the turns of a voice coil or winds by 80 to 120% of the number of turns of the voice coil in the reverse direction thereof is attached on the upper and outer circumference of the lower plate being the void of the driving portion. Thus, the negative current source which causes the AC magnetic field is counteract free from the frequencies to lessen the amount of the AC magnetic flux and the sound pressure distortion is minimized, thereby improving the sound quality of the speaker unit.

However, because the voice coil actually shakes upward and downward, complete compensation effect cannot be expected. Moreover, the compensation coil also being subjected to both the upward & downward force and reversely directional force must be firmly attached to the pole cap on the lower plate. An embodiment for solving these problems is illustrated FIGS. 15 and 16.

FIGS. 15 and 16 show another embodiment of the speaker according

to the present invention, in which the same reference numerals used in FIGS. 11 and 12 designate the like parts, and thus detailed description of them will be omitted.

As can be noted in FIGS. 15 and 16, a compensation coil 140 winds in the reverse direction of a voice coil 123 is installed along a groove formed in the lower portion of the void in a driving portion 110, in which the compensation coil 140 winds by approximately a half of the number of turns of the voice coil 123 and serially connected thereto. The compensation coil 140 preferably winds by the number of turns of 40 to 60% with respect to the voice coil 123, and a half of that of the voice coil 123 is more preferable.

As shown in FIG. 16, the compensation coil 140 is installed around the center of the lower plate 113 or adjacent thereto in the reverse direction. The main function of the compensation coil 140 is to counteract the AC magnetic field generated by the voice coil 123 or adjust the flow of the magnetic flux rather than to counteract the current source as described with reference to FIGS. 11 and 12. This is for achieving the offset effect of the AC magnetic field or the flow of the magnetic flux by the compensation coil 140 as shown in FIG. 17. As can be noted in FIGS. 17 and 18, in connection with the void magnetic flux crossing throughout the voice coil 140, the positive and negative form a good symmetry to decrease overall void AC magnetic flux Φac by using the compensation coil 140. The decrease of the void AC magnetic flux Φac denotes the reduction of the distortion component of the second harmonic frequency as shown in the foregoing equation III.

In the speaker according to another embodiment of the present invention, the current (negative current) flows along the voice coil 123 under the state that the DC magnetic flux is interlinked in the void between the upper plate 114 and lower plate 113 by the main magnet 115 and auxiliary magnet 112, which initiates the up-and-down movement of the voice coil 123 in conformity with the Fleming's rule of left hand.

By the upward and downward vibration of the voice coil 123, the vibrating plate 121 integrally formed with the voice coil 123 also vibrates upward and downward, thereby generating a predetermined sound pressure.

At this time, when the current flows along the voice coil 123 of the vibrating plate 121, the AC magnetic flux is produced, and another AC magnetic flux occurs by the compensation coil 140 serially connected to the voice coil 123.

In other words, the AC magnetic flux produced by the voice coil 123 is distributed in the upper portion of the void to be symmetrical to another AC magnetic flux, so that the current phase difference between the voice coil 123 and compensation coil 140 becomes 180° to obtain the offset effect of the AC magnetic flux.

More specifically, as shown in FIG. 17, the center of the AC magnetic flux from the voice coil 123 is placed on the radius direction of the void portion to counteract the positive and negative AC magnetic flux of the void, thereby lessening the amount of the AC magnetic flux produced.

Therefore, the speaker according to the present invention, as shown

in FIGS. 17 to 19, the AC magnetic flux from the void between the upper and lower plates 114 and 113 is little in quantity by means of the compensation coil 140 attached on the groove in the lower portion of the void regardless of the frequencies, and the AC magnetic flux component in the void is produced while forming a perfect symmetry by positive and negative to reveal the excellent offset effect of the AC magnetic field.

That is, the excellent offset effect of the AC magnetic field by the compensation coil 140 denotes that, when the vibrating plate 121 integrally formed with the voice coil 123 vibrates upward and downward along with the up-and-down movement of the voice coil 123 by the current (negative current) flowing through the voice coil 123, the AC magnetic flux inevitably generated by the current of the voice coil 123 is decreased by the compensation coil 140, and the imperfect balance of the magnetic field is prevented in the void between the upper plate 114 and lower plate 113. So the distortion with respect to the up-and-down movement of the voice coil 123 is prevented and compensated to minimize the sound pressure distortion.

Also, the pole cap 16 of the lower plate 113, which was the requisite component of the conventional technique is not needed to reduce the AC magnetic flux, so that the induced current at the upper and lower plates 114 and 113 is decreased, and the thermal loss (iron loss) and hysteresis loss are reduced.

In the speaker according to the above embodiments of the present invention, since the compensation coil which winds by approximately a half the turns of the voice coil in the reverse direction thereof is

attached on the groove between the upper and lower plates. Thus, the AC magnetic flux is counteract free from the frequencies to lessen the amount of the AC magnetic flux and the sound pressure distortion is minimized, thereby improving the sound quality of the speaker unit.

As described above, a compensation coil is attached around a void to be close to a voice coil installed around the void between upper and lower plates to minimize sound pressure distortion. Therefore, sound quality of a speaker unit is improved, and the loss of a magnetic circuit can be minimized.

While the present invention has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be effected therein without departing from the spirit and scope of the invention as defined by the appended claims. For example, the compensation coil may be formed in any portion of the void in the driving portion - not only in the outer circumference of the lower plate, but also in the inner surface of the upper plate and the inner surface of the main magnet which is a DC magnetic field generation apparatus).

CLAIMS

1. A speaker including a DC magnetic field generation apparatus having first and second magnets, an upper plate and a lower plate forming a magnetic path of said DC magnetic field generation apparatus, and a voice coil for converting an electrical sound signal into a mechanical sound signal in a void between said upper plate and lower plate, further comprising

AC magnetic flux offset means formed to allow magnetic flux produced for counteracting an AC magnetic flux component induced between said voice coil and said upper and lower plates to have a phase difference of 180° with AC magnetic flux.

2. A speaker as claimed in claim 1, wherein said AC magnetic flux offset means is formed of sound current source offset means having a phase difference of 180° with said AC current component for counteracting said AC current component produced by said voice coil.

3. A speaker as claimed in claim 1, wherein said AC magnetic flux offset means is formed of AC magnetic field offset means having a phase difference of 180° with an AC magnetic field for counteracting said AC magnetic field induced between said voice coil and first magnet.

4. A speaker as claimed in claim 2, wherein said sound current source offset means is a compensation coil winding as many as 80 to 120% with respect to the number of turns of said voice coil on an outer circumference of an upper portion of said lower plate projecting at a

groove in a lower portion of said void, and serially connected to said voice coil.

5. A speaker as claimed in claim 3, wherein said AC magnetic field offset means is a compensation coil winding as many as 40 to 60% with respect to the number of turns of said voice coil on the central portion of upper and lower ends of said lower plate projecting at said groove in said lower portion of said void, and serially connected to said voice coil.

6. A speaker as claimed in claim 3, wherein said compensation coil winds around said lower end of said lower plate projecting at said groove in said lower portion of said void.

7. A speaker substantially as hereinbefore described with reference to any one of the accompanying figures 11 to 19.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 -22-
(The Search report)

Relevant Technical Fields (i) UK Cl (Ed.M) H4J (JCA, JDJ, JGC) (ii) Int Cl (Ed.5) HO4R 9/00, 9/02, 9/06	Application number GB 9407916.7 Search Examiner P J EASTERFIELD Date of completion of Search 11 JULY 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1 TO 6

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2235350 A	(BIRT)	1 TO 4
X	GB 2010639 A	(MATSUSHITA)	1 TO 3
X	EP 0492142 A2	(NOKIA)	1 TO 3

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

FIG. 1
PRIOR ART

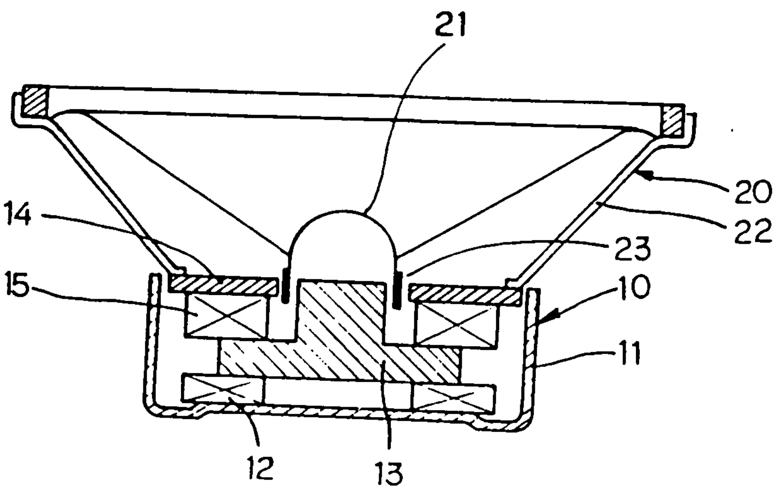

FIG. 2
PRIOR ART

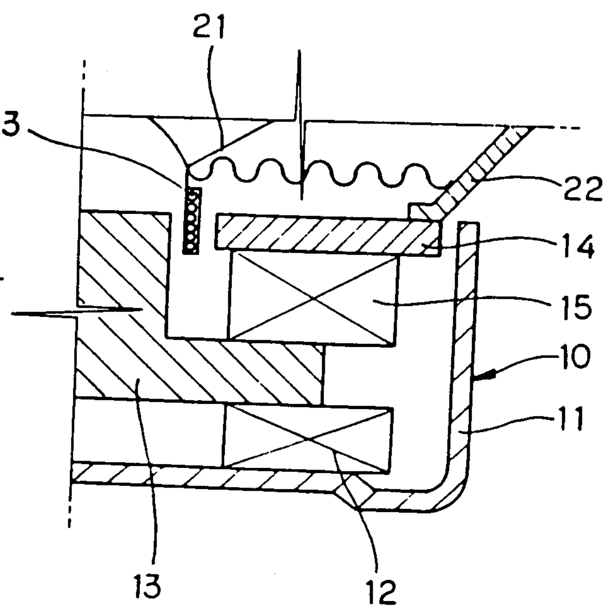

FIG.3
PRIOR ART

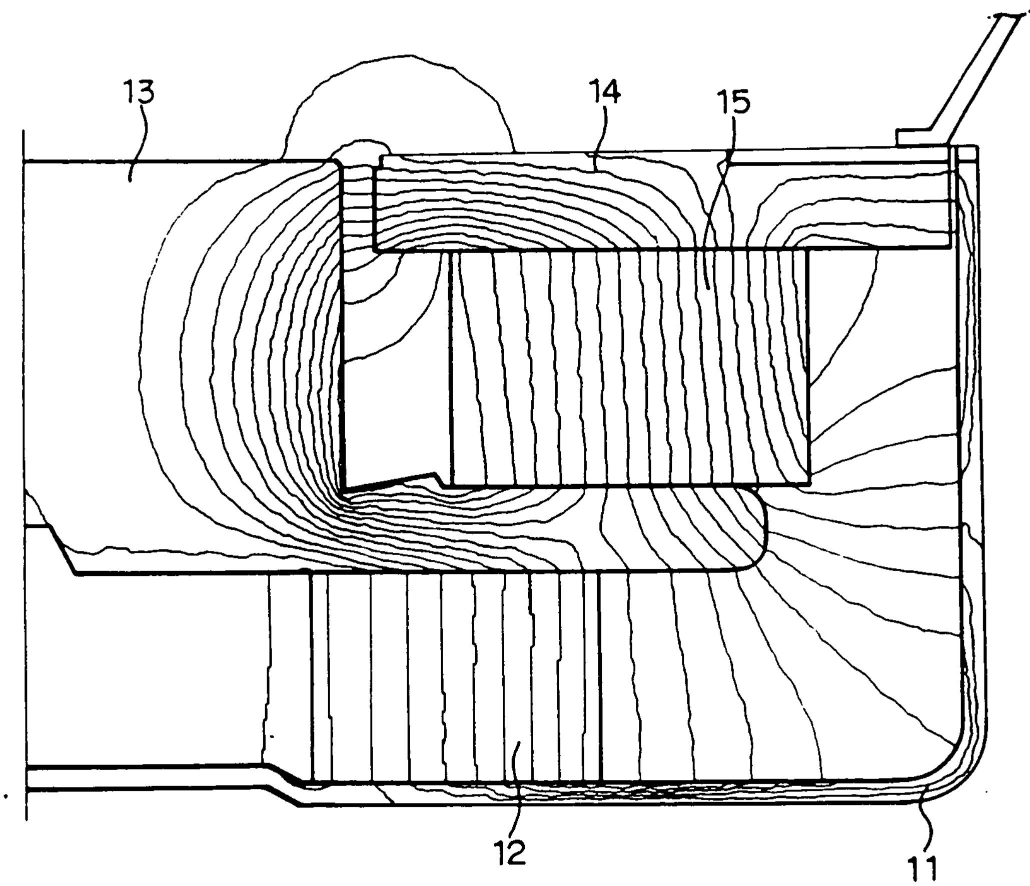

FIG.4A
PRIOR ART

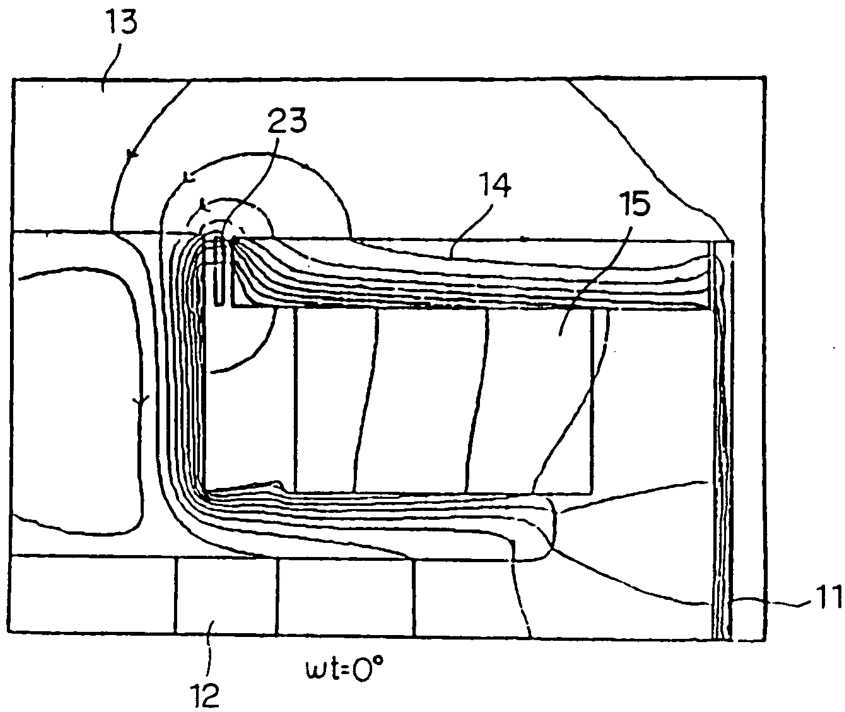

FIG.4B
PRIOR ART

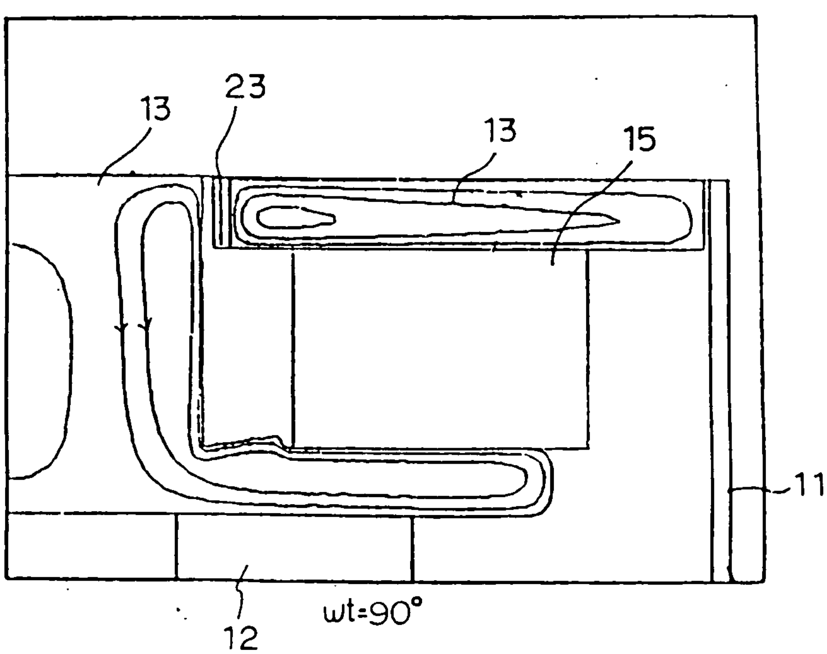

FIG.4C
PRIOR ART

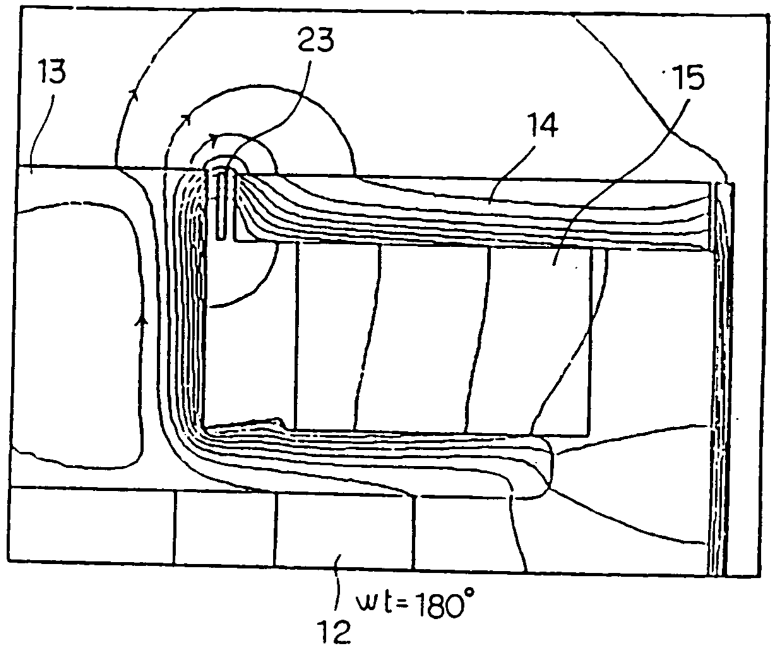

FIG.4D
PRIOR ART

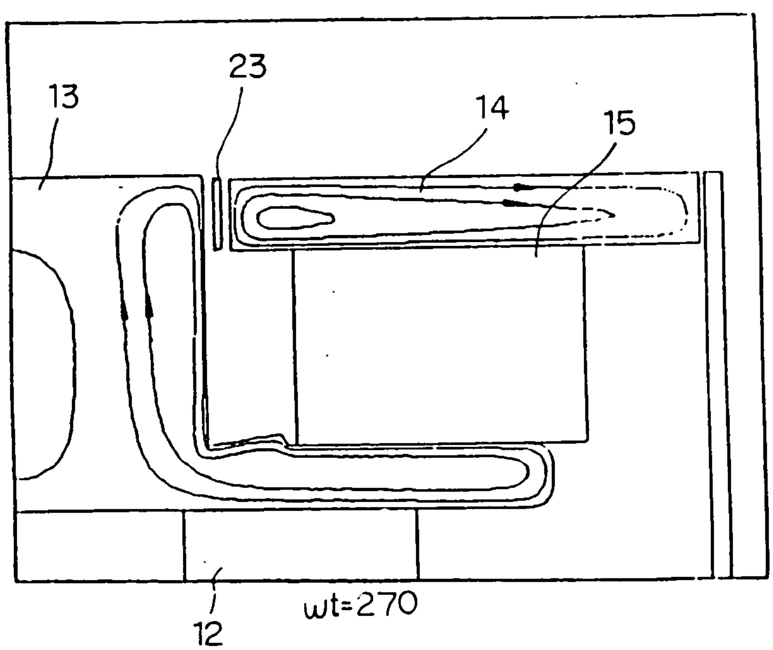

FIG.5A
PRIOR ART

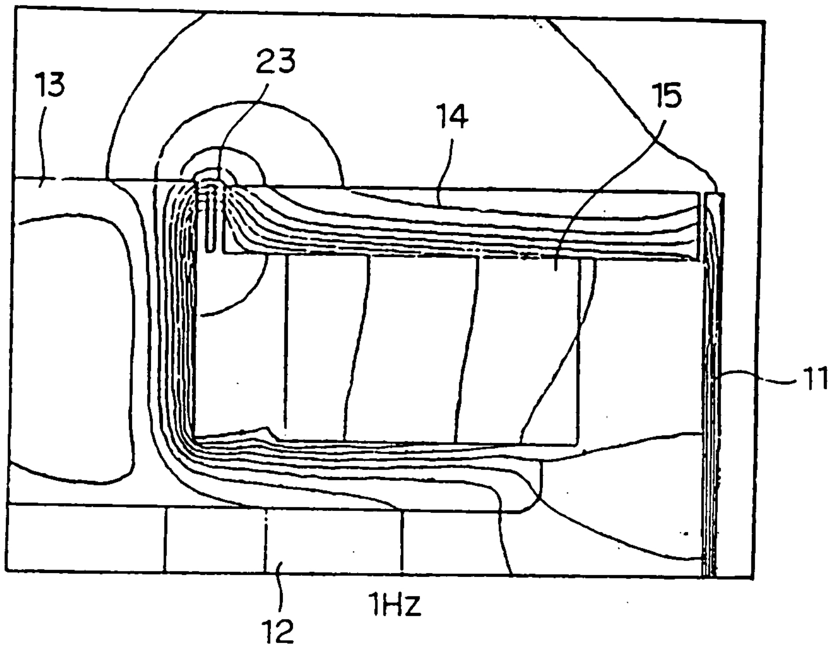

FIG.5B
PRIOR ART

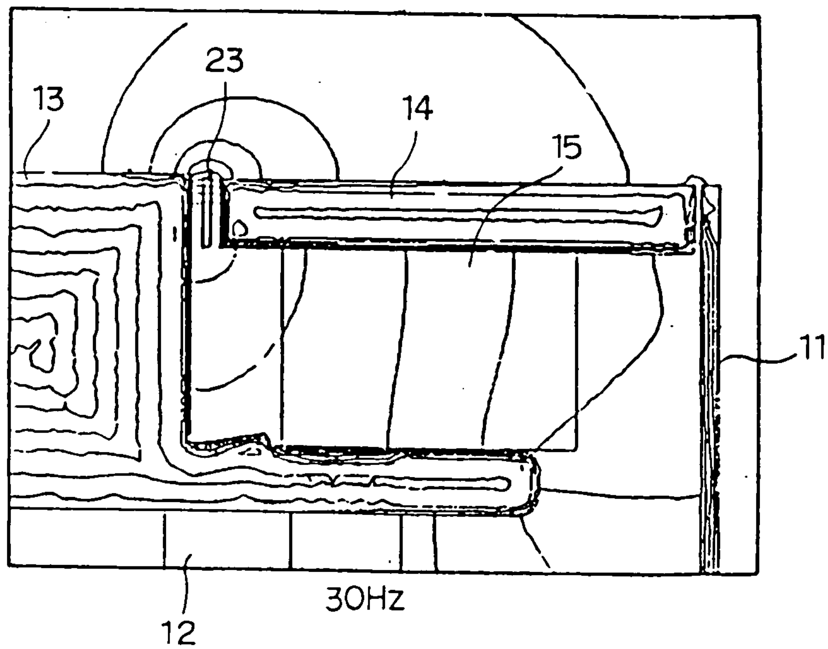

FIG.5C
PRIOR ART

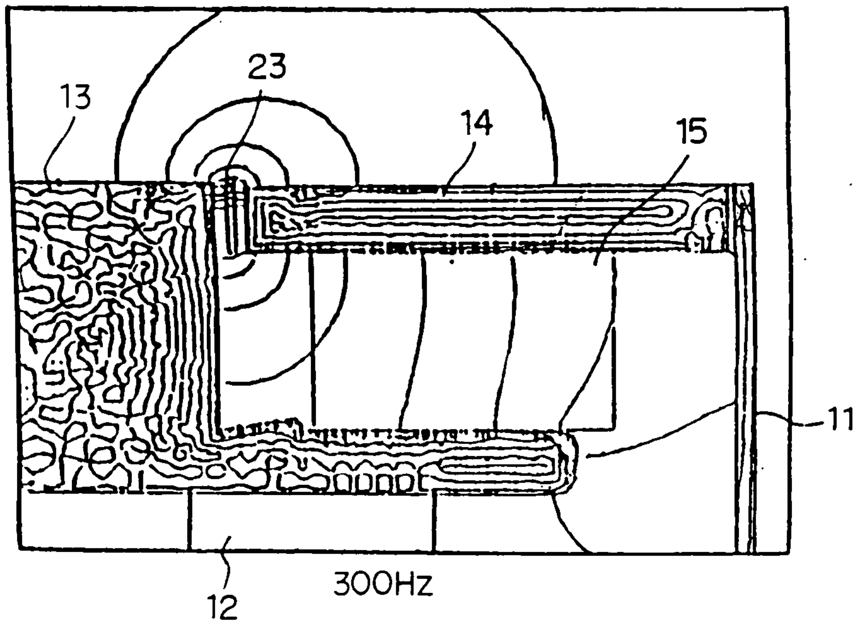

FIG.5D
PRIOR ART

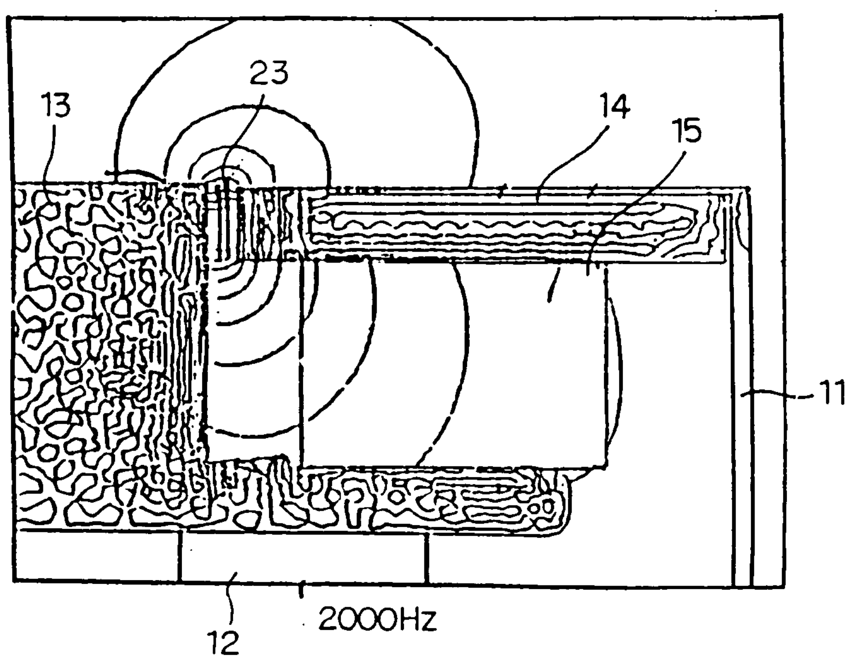

FIG.6

PRIOR ART

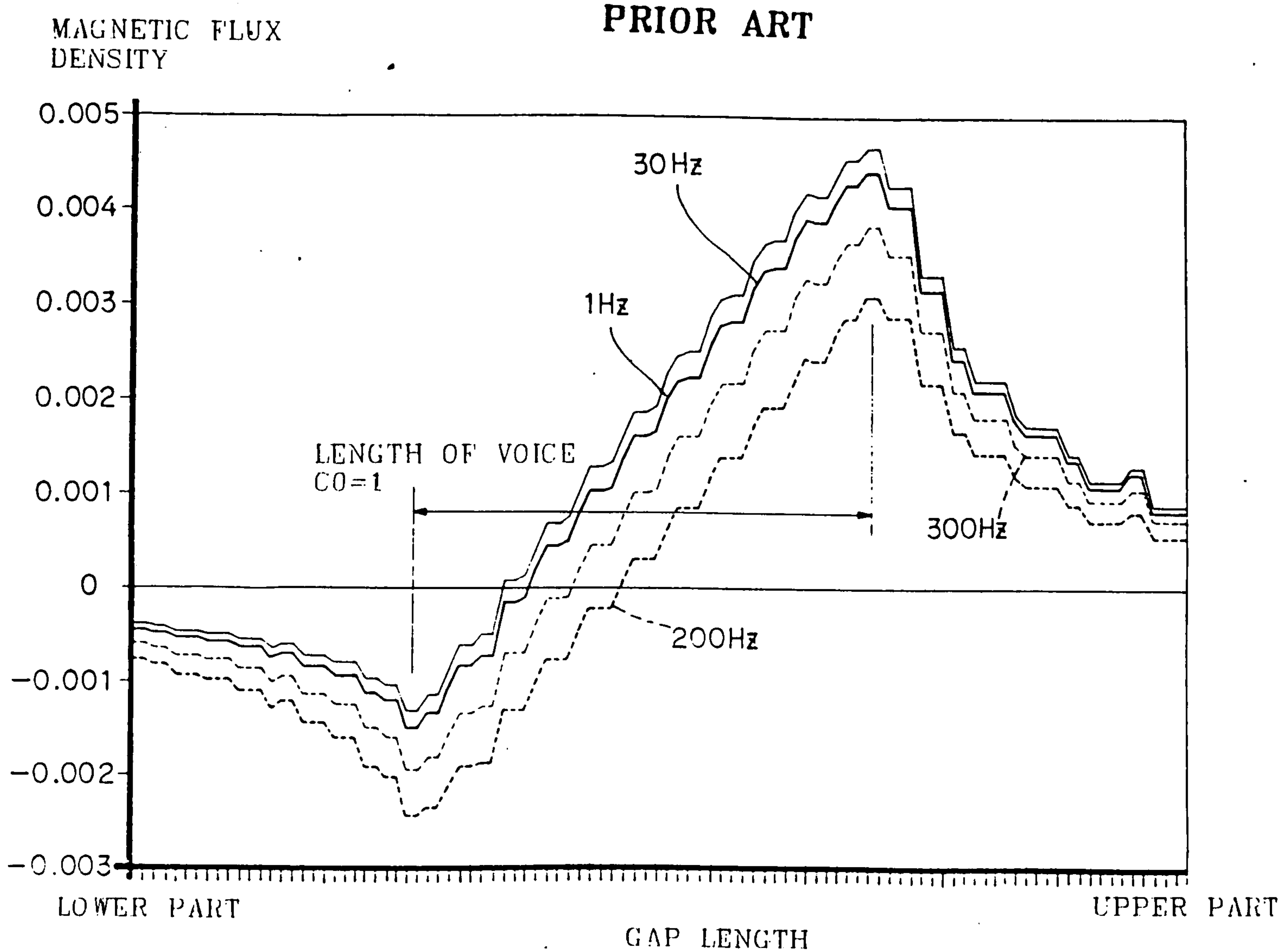

FIG.7
PRIOR ART

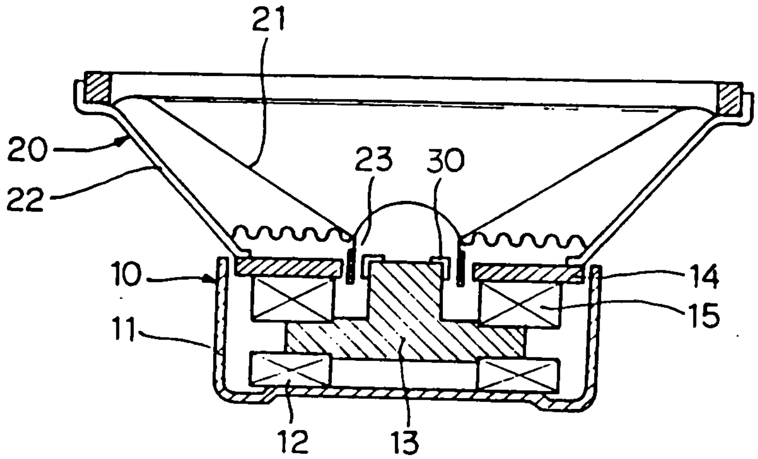

FIG.8
PRIOR ART

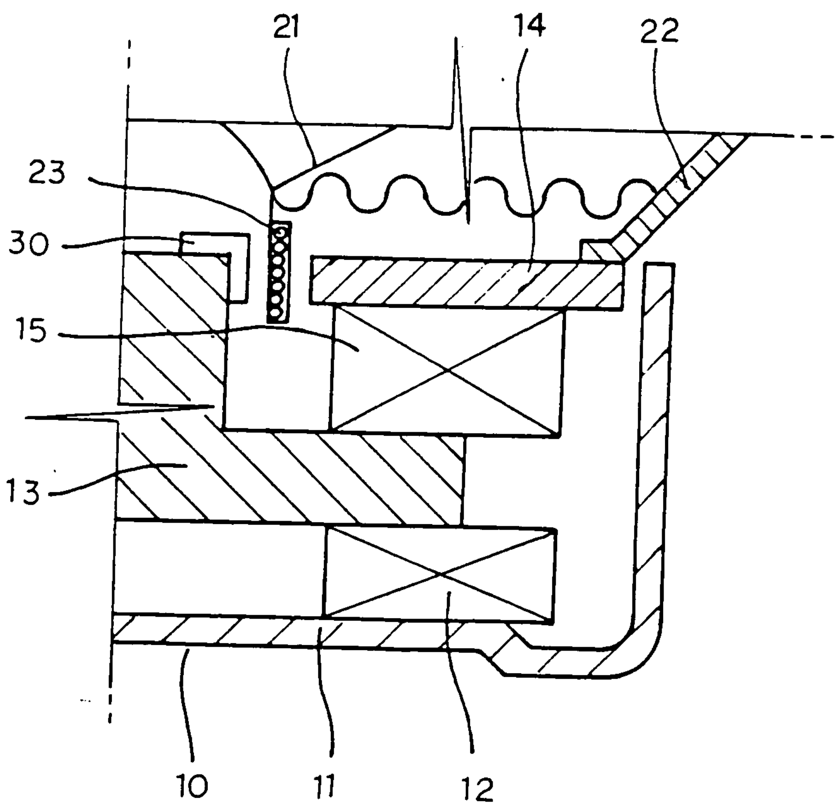

FIG.9
PRIOR ART

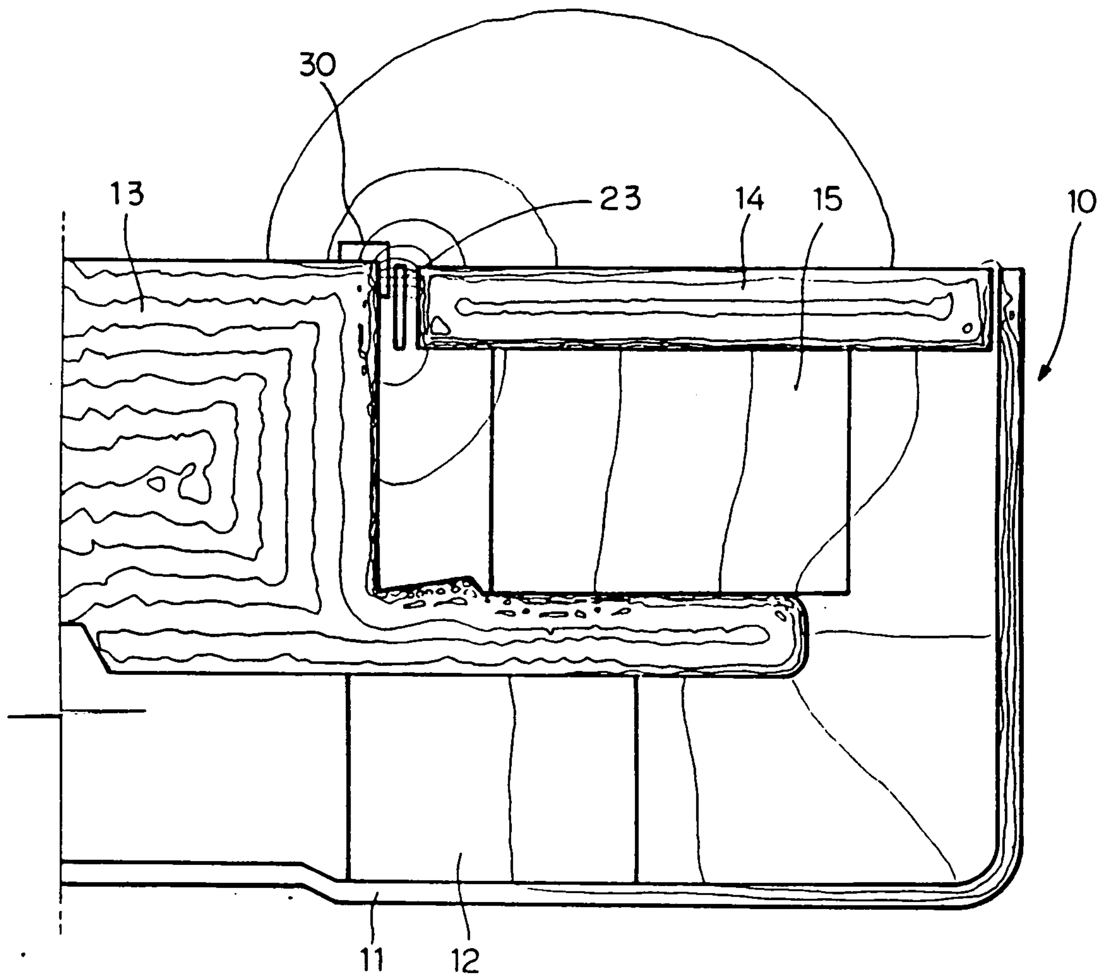

FIG.10
PRIOR ART

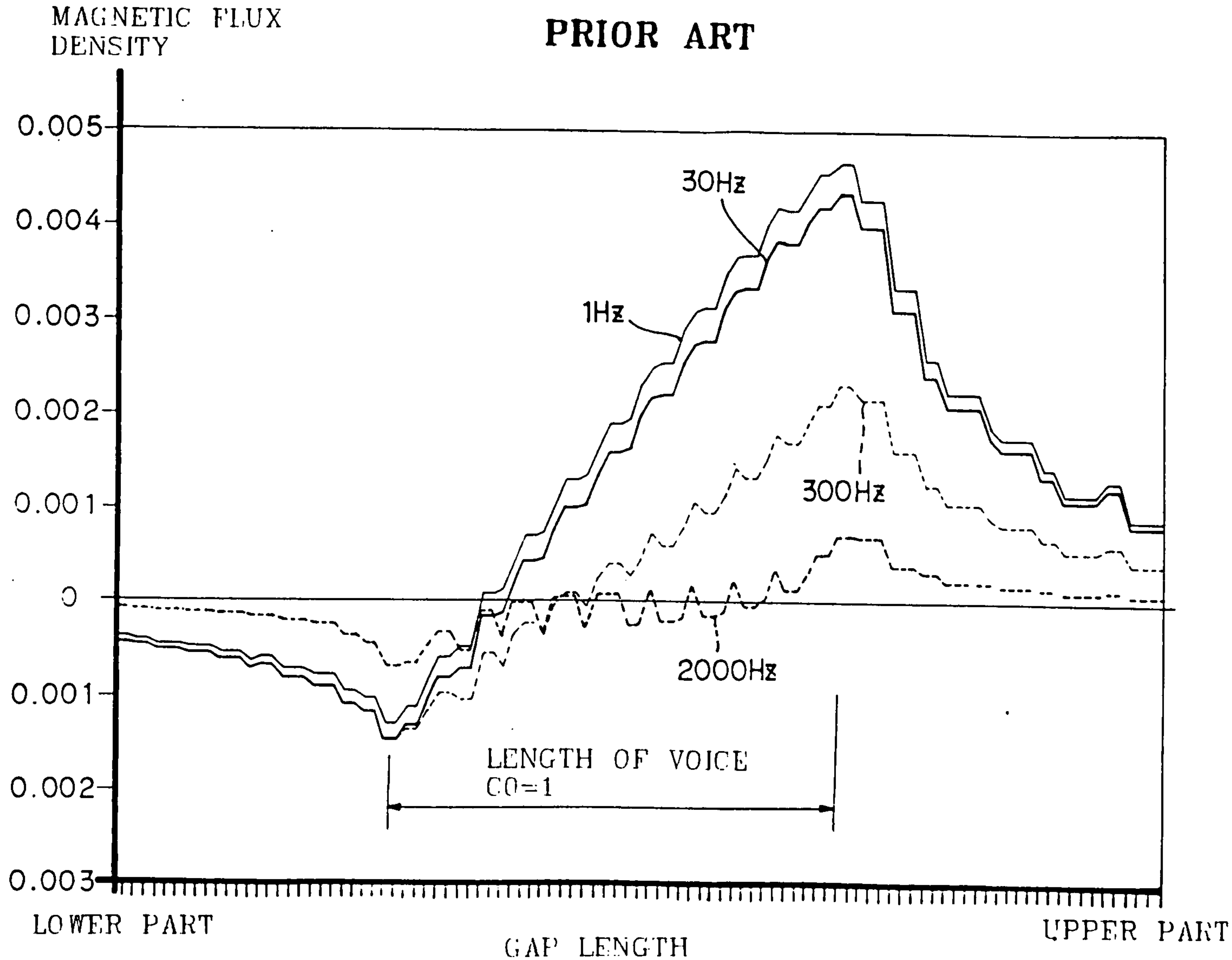

FIG. 11

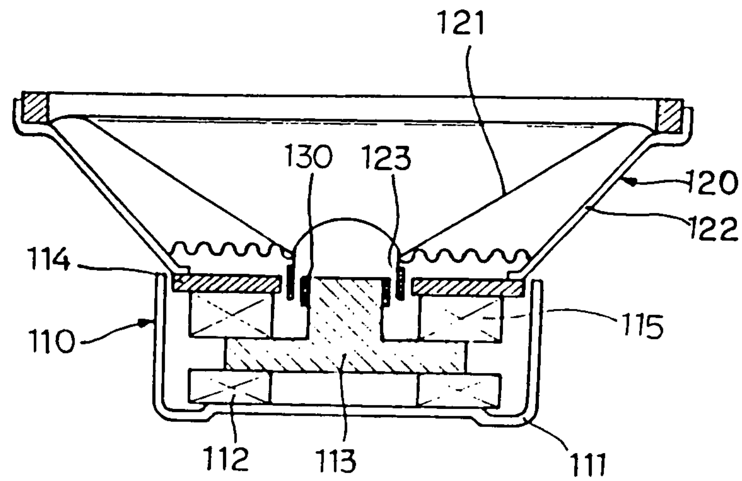
121
130
123
120
122
114
110
115
112
113
111

FIG. 12

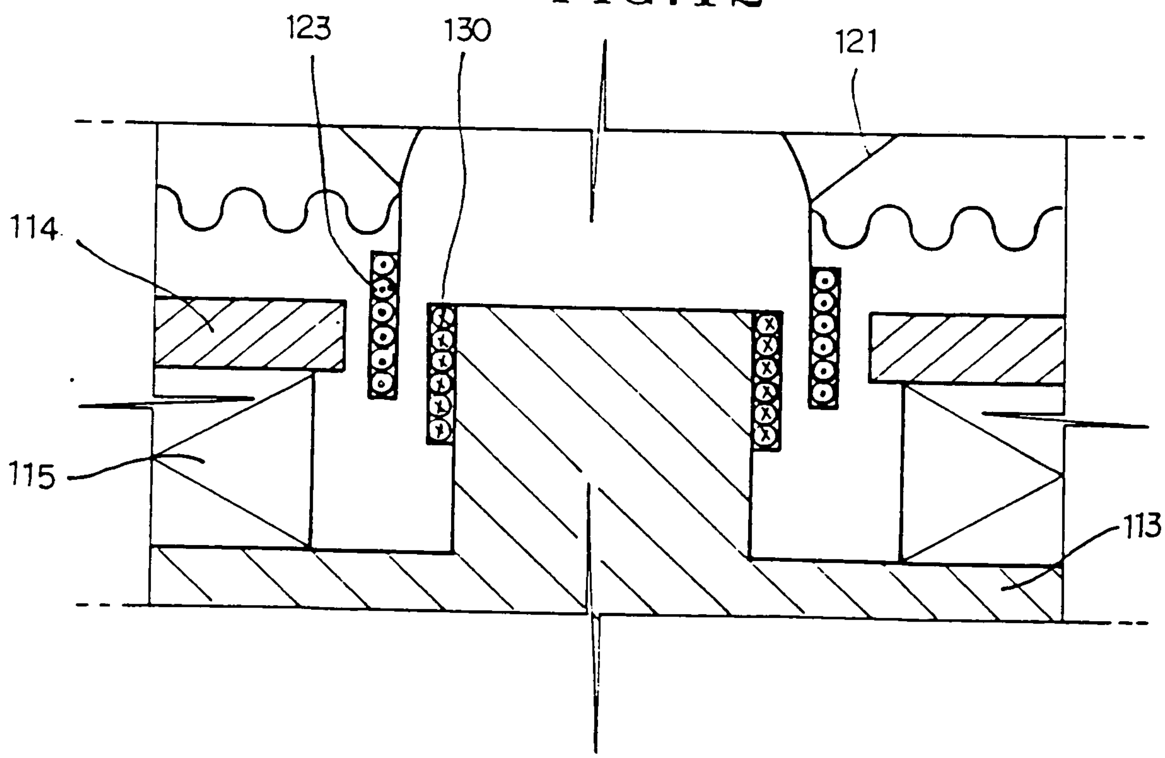
123
130
121
114
115
113

FIG.13

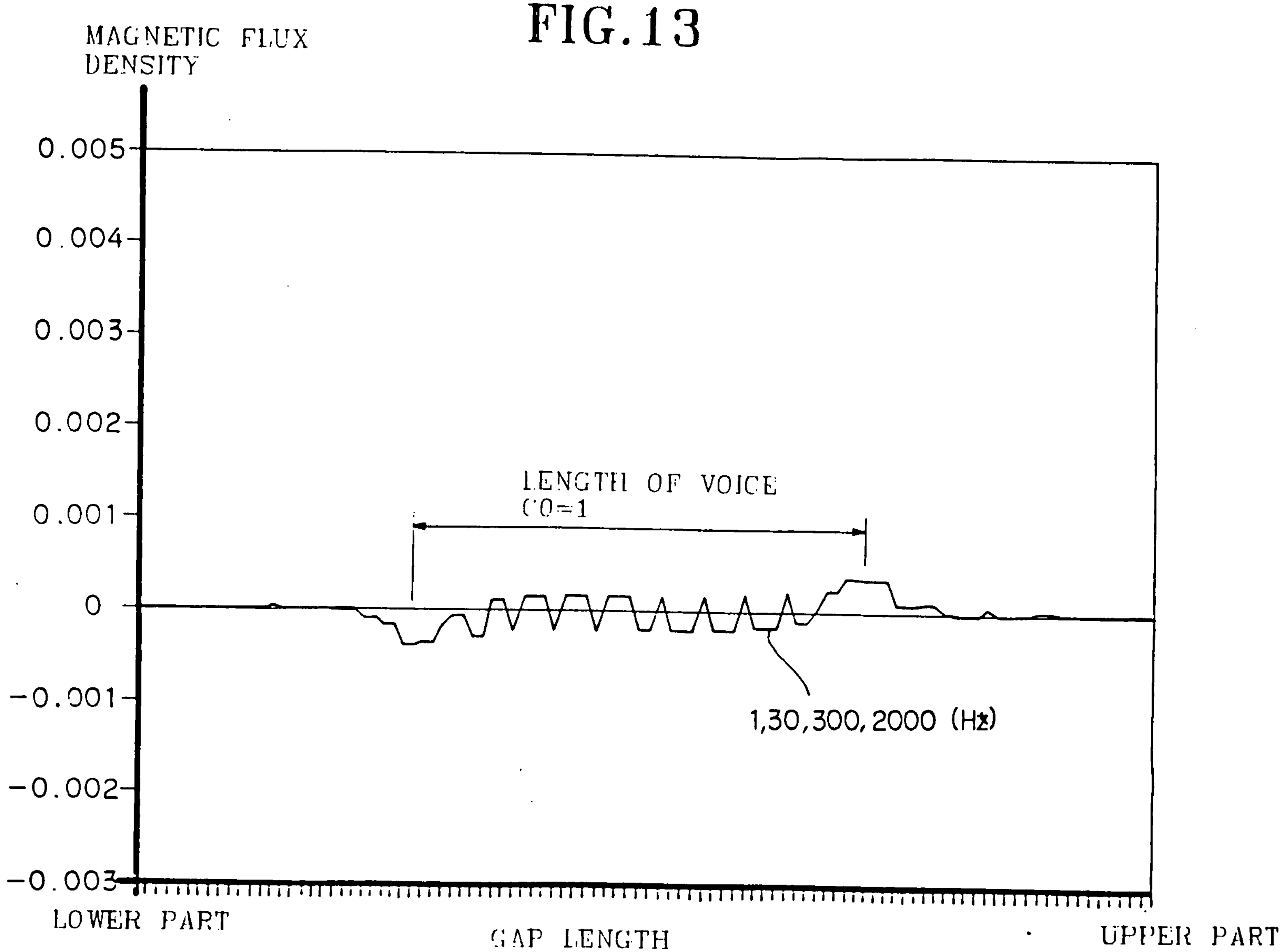
MAGNETIC FLUX DENSITY
0.005
0.004
0.003
0.002
0.001
0
−0.001
−0.002
−0.003
LENGTH OF VOICE
C0=1
1,30,300,2000 (Hz)
LOWER PART
GAP LENGTH
UPPER PART

FIG.14

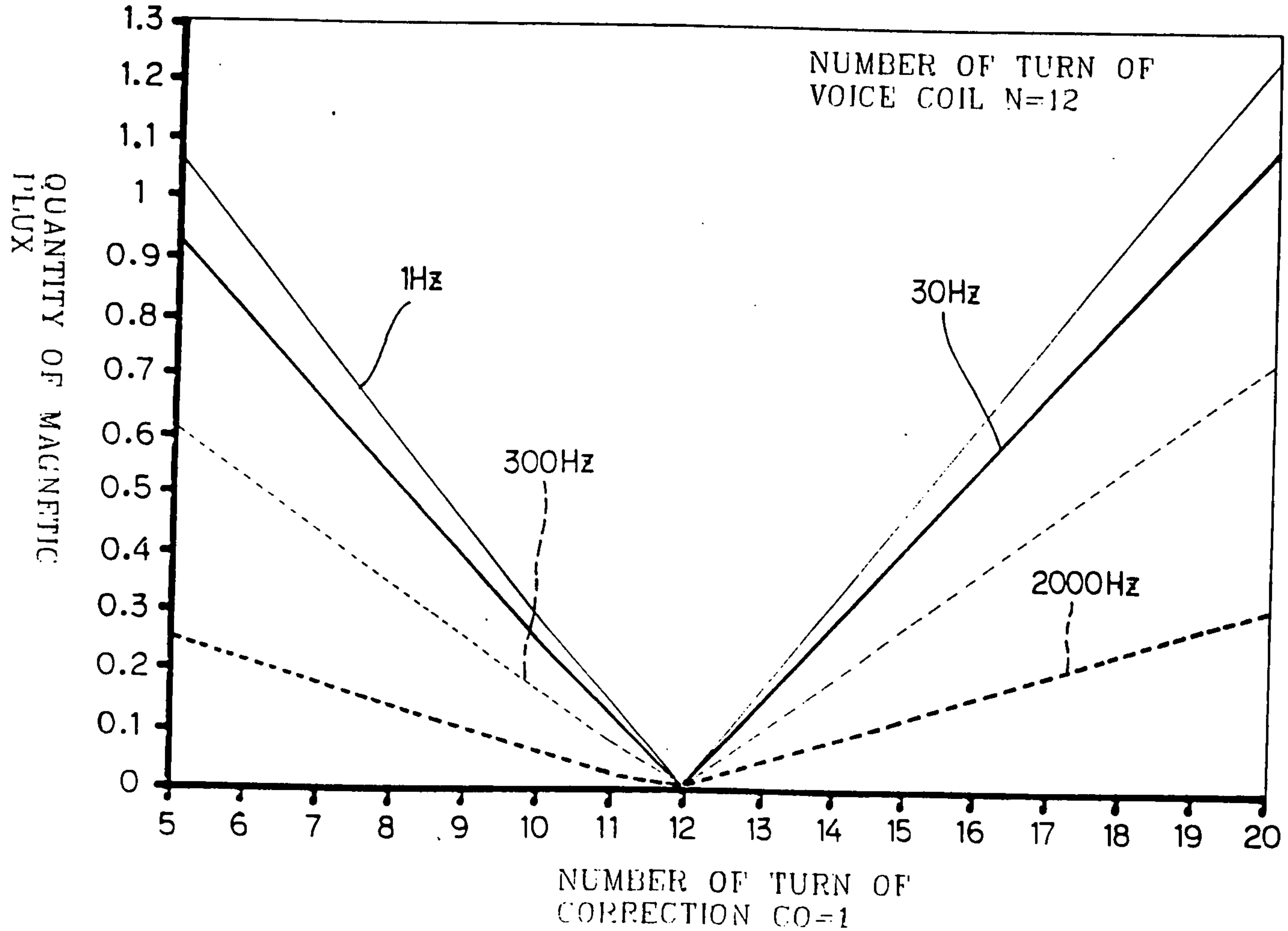
NUMBER OF TURN OF
VOICE COIL N=12
1Hz
30Hz
300Hz
2000Hz
QUANTITY OF MAGNETIC FLUX
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
NUMBER OF TURN OF
CORRECTION CO=1

FIG.15

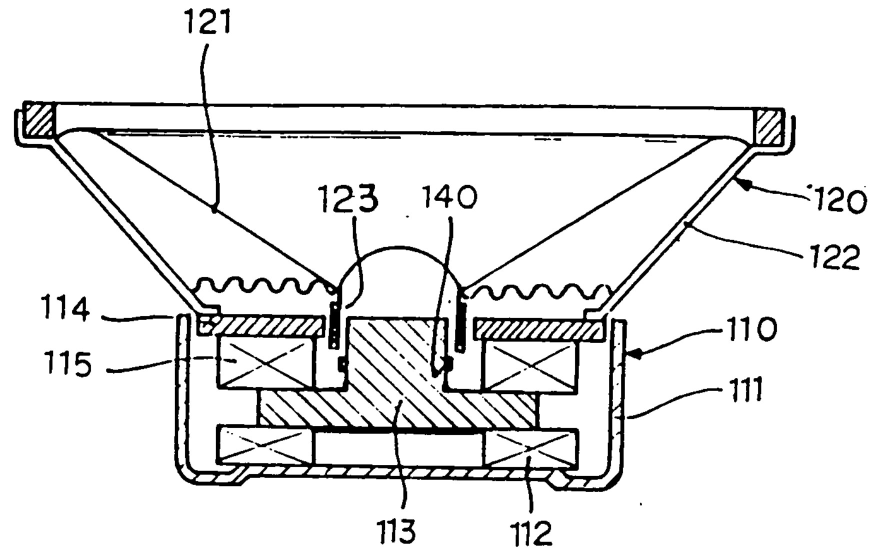
121
123
140
120
122
114
110
115
111
113
112

FIG.16

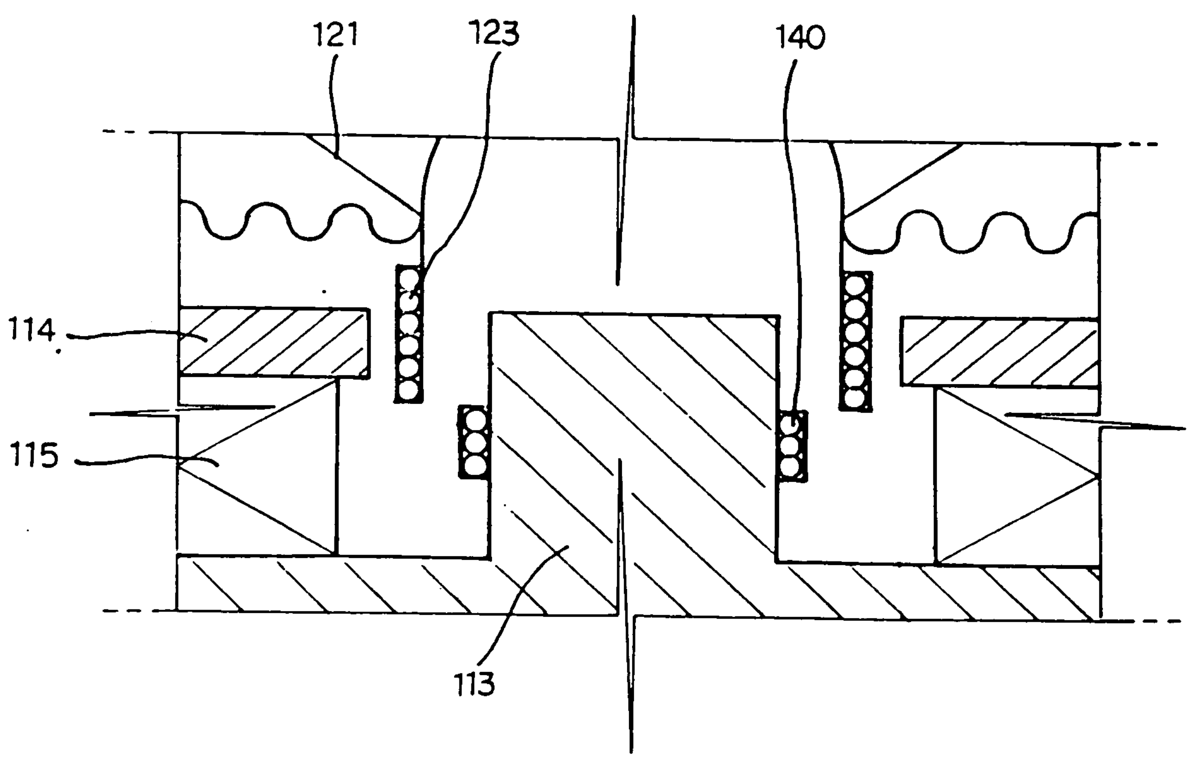
121
123
140
114
115
113

FIG.17

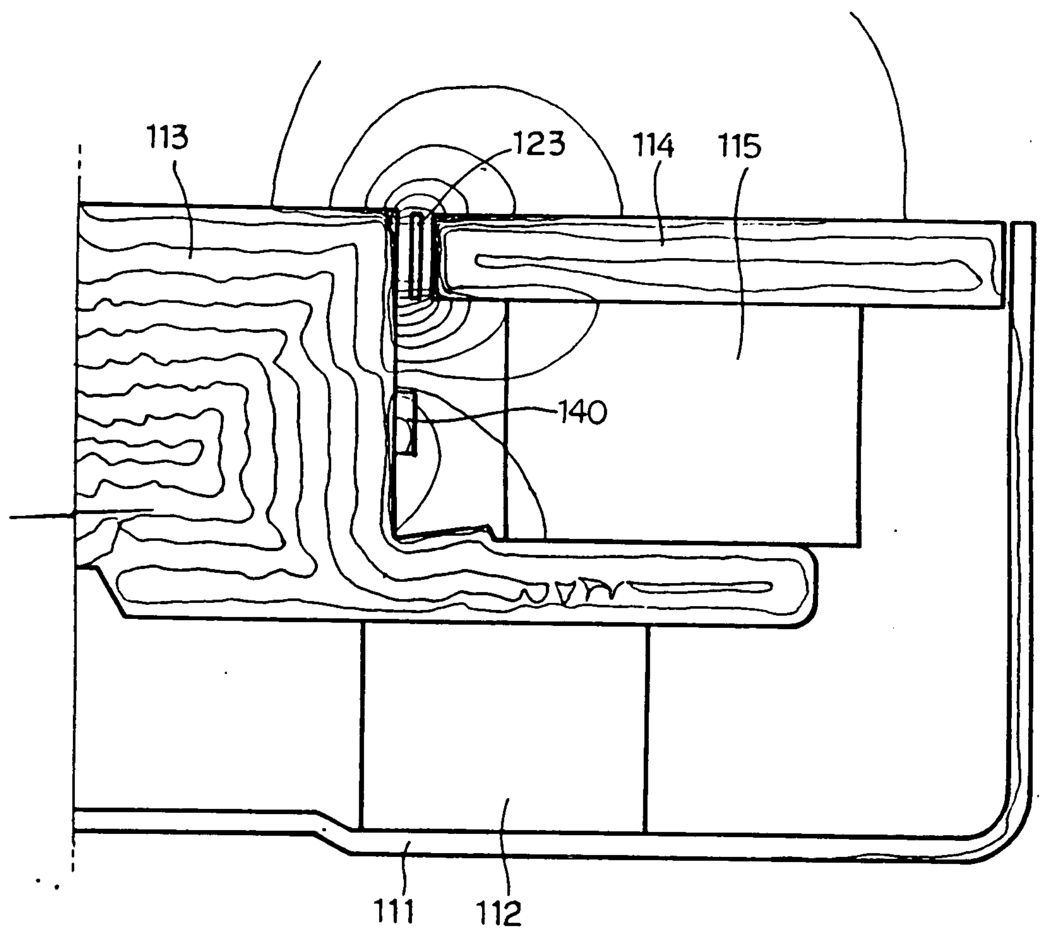

FIG.18

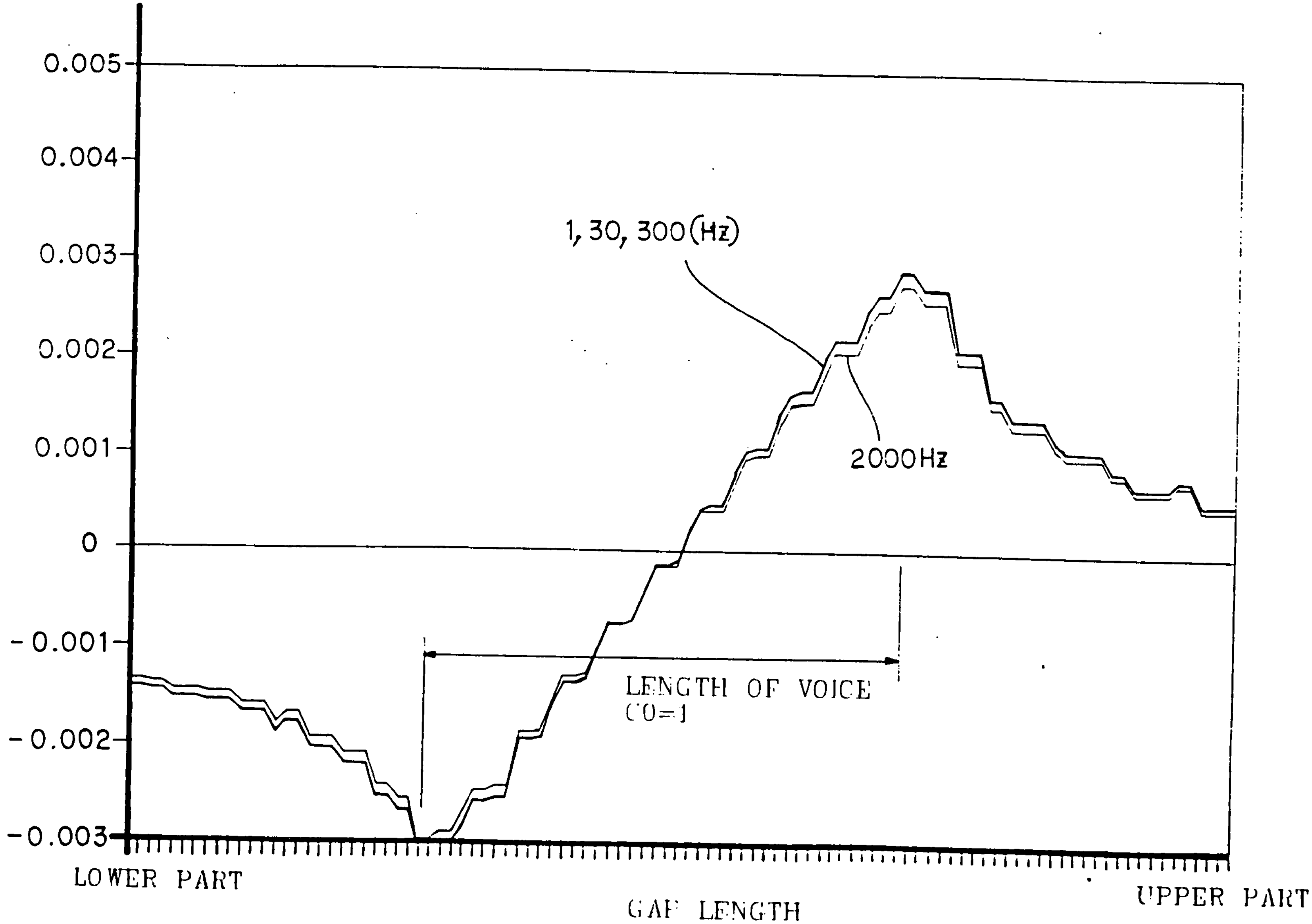
MAGNETIC FLUX DENSITY
0.005
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
1, 30, 300 (Hz)
2000Hz
LENGTH OF VOICE
C0=1
LOWER PART
GAP LENGTH
UPPER PART

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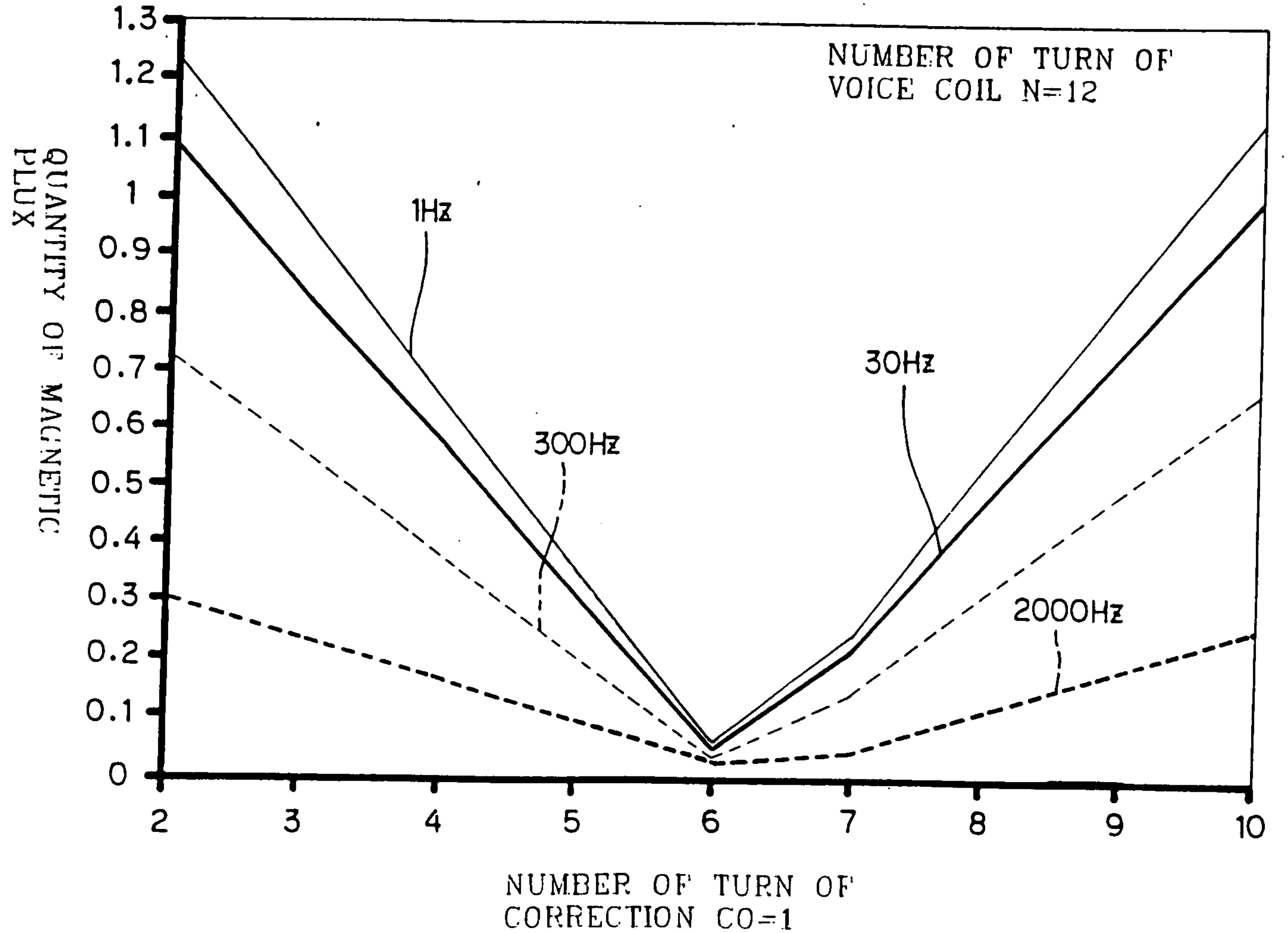
FIG.19



NUMBER OF TURN OF VOICE COIL N=12
1Hz
30Hz
300Hz
2000Hz
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
3
4
5
6
7
8
9
10
QUANTITY OF MAGNETIC PLUX
NUMBER OF TURN OF CORRECTION CO=1